

- MASTER SPECIFICATION -

SECTION 16500

ENERGY EFFICIENT LIGHTING TECHNOLOGIES
FOR EXISTING FEDERAL FACILITIES

May 1998

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PART 1.0 - GENERAL

1.01 SCOPE

General requirements for lighting systems including coordination, definitions, quality assurances, submittals, mockup, samples and general responsibility for a complete job.

1.02 GENERAL REQUIREMENTS

Do not submit bid with uncertainty, nor proceed with work with uncertainty nor without prior authorization. The intent of this specification and accompanying or applicable drawings, is to provide a job complete in every respect. Take full responsibility for this result.

IDENTIFY GOVERNMENT REPRESENTATIVE RESPONSIBLE FOR
ADMINISTERING THE CONSTRUCTION CONTRACT FOR THE USER AGENCY
AND REFERENCE CONSISTENTLY THROUGHOUT SPECIFICATION.

1.03 COORDINATION

- A. Check for adequacy of headroom and non-interference with other equipment, such as ducts, pipes or openings. All conflicts shall be brought to Contracting Officer's attention before proceeding with Work.
- B. Verify ceiling conditions including ceiling material thickness, insulation, and suspension system. Furnish appropriate mounting details for specified luminaire or lighting component. Contracting Officer shall approve mounting details.
- C. Verify adequate grounding of building and luminaires for work specified.

1.04 QUALITY ASSURANCES

A. WARRANTY

- 1. For a period of one year after the Agency's initial acceptance and establishment of the beginning date of the warranty period, and at no additional cost, promptly provide and install replacements for luminaires or components thereof which in the opinion of the Contracting Officer are defective in materials or workmanship; or repair installed equipment at the job site to the Contracting Officer's satisfaction. For any time during the warranty period that luminaires are not fully functional due to defects in materials or workmanship, provide or pay for and install and remove suitable and adequate temporary lighting. Additionally, warrant replacement luminaires or components to be free of defects in workmanship or materials for a period of one year following replacement, and replace any defective replacements.

2. Provide products of firms regularly engaged in the manufacture of equipment and components of similar types and ratings to those specified. Such similar products shall have been in satisfactory use in similar applications for not less than two years.

B. SUBSTITUTIONS

1. Substitutions will only be considered if the product is a true equal and there is an obvious advantage for the Agency. Substitutions shall only be accepted after review and written approval of (specifier).
2. Submit samples, catalogue cuts, and complete photometric reports. Document product cost including a proposal of the net change, if any, in the contract sum. Written documentation shall clearly show manufacturer's compliance with specification requirements and include the FEMP Lights' "Manufacturer Product Initiative Certification" with exceptions or variations indicated. Submit written requests for proposed component and luminaire substitutions to Contracting Officer.
3. Excessive delivery times shall not be an acceptable cause for substitution unless all acceptable manufacturers have been contacted, and the problem is brought to the attention of Contracting Officer within two weeks after contract award.

C. EQUIPMENT COMPATIBILITY

Provide similar luminaires and components fabricated by one manufacturer to simplify maintenance and replacement.

D. REGULATORY AGENCIES

1. Provide luminaires fabricated, wired and installed in compliance with current edition of applicable city, state, and national codes. Provide luminaires which conform to additional regulations necessary to obtain approval for use of specified luminaires in locations shown.
2. Provide interior luminaires and electrical components listed and labeled by Underwriters Laboratories (UL) or ETL Testing Laboratories. Lighting equipment shall comply with UL standards pertaining to interior luminaires including: UL 1570 Fluorescent Lighting Fixtures; UL 1572 HID Lighting Fixtures; UL 1029 HID Ballasts; UL 542 Lampholders, Starters and Starter Holders for Fluorescent Lamps.
3. Provide luminaires which comply with applicable requirements of the National Electrical Manufacturers Association (NEMA) LE 4 pertaining to recessed luminaires and with the National Fire Protection Association (NFPA) NFPA 70 "National Electrical Code" (NEC), as applicable to construction and installation of interior building luminaires.
4. Comply with all relevant Federal, State, Local, and Agency guidelines when disposing of lighting waste:

- a. Most fluorescent, compact fluorescent, and HID lamps require special handling and disposal procedures.
- b. Most ballasts containing PCB's require require special handling and disposal procedures.
- c. Disposal guidelines are available on the internet from the US Environmental Protection Agency at www.epa.gov/GCDOAR/waste.html.

1.05 SUBMITTALS

A. GENERAL

1. Shop drawings, samples, test data and certificates shall be submitted for approval in accordance with requirements of the Contract Documents. Luminaire shop drawings shall be submitted in booklet form with a separate sheet for each luminaire type. Each sheet shall clearly indicate proposed luminaire "type" designation, luminaire lamp, and ballast designation. luminaires or other materials shall not be shipped, stored or installed into the Work until submitted shop drawings, samples, catalogue cuts, test data, certificates, or other material has been approved. Luminaire modifications shall be made in accordance with Contracting Officer's submittal comments.
2. Prior to final inspection, provide a complete set of operating and maintenance manuals. Include technical data sheets and parts ordering information.

USE PARAGRAPH BELOW ONLY IF SPECIFYING RETROFIT REFLECTORS.

3. For applications of specular retrofit reflectors to existing luminaires, Contractor shall submit a computer generated plot of illuminance at a work plane height of 2'-6" above finished floor, and exitance of walls and ceilings for typical spaces indicated below. Calculation procedure shall model partial height partitions, architectural elements, furnishings, or obstructions above 2'-6". Include documentation identifying the computer program used and input forms listing assumptions for room reflectances, initial lamp lumens, ballast factor, luminaire dirt depreciation, lamp lumen depreciation and room surface dirt depreciation. Photometric data shall be generated from existing luminaire with proposed reflector, and tested by independent testing lab.

PROVIDE LIST OF TYPICAL SPACES TO BE MODELED HERE.

B. SHOP DRAWINGS

1. Submit shop drawings for each luminaire type and component, except where specified luminaires are standard, unmodified, "off-the-shelf" units, or fully described by catalogue cuts. Submit shop drawings in the form of six (6) copies and catalogue cuts in nine (9) photocopies.

2. Shop drawings shall indicate materials, finishes, metal gauges, overall and detail dimensions, sizes, electrical and mechanical connections, fasteners, welds, joints, end conditions, provisions for the work of others, and similar information. Shop drawings shall include pertinent mounting details including suspended ceiling construction. Indicate complete details of luminaire, including manufacturer's catalogue numbers for sockets, ballasts, lightshields, switches and type of wiring, and targeting and locking devices for adjustable luminaires. Indicate type and extent of approved inert insulating materials to prevent electrolytic corrosion at junctions of dissimilar metals. Standard catalogue cuts shall be supplemented by additional drawings if information or descriptions listed above are not included in the cuts.
3. Submit catalogue cuts of lamps and ballasts to be provided for each luminaire.

INCLUDE BLANK CERTIFICATION FORM IF THE FOLLOWING
PARAGRAPH IS INCLUDED.

4. Submit a completed manufacturer certification form for every product specified.

C. DATA

1. Submit nine (9) photocopies of photometric reports for standard, "off-the-shelf" luminaires as follows:
 - a. Submit photometric reports at the time the manufacturer's product data sheets are submitted.
 - b. Photometric reports shall be prepared by an independent testing laboratory for the specific lamp/ballast combination specified whenever:
 - 1) Proposed luminaire is a substitution.
 - 2) **OR** if more than fifty (50) luminaires of that type are called for.
 - c. For all other standard luminaires photometric reports may be prepared by the manufacturer's in-house laboratory. Reports must be generated for the exact number and type of lamp specified unless there are fewer than ten (10) luminaires of that type called for.
2. Submit nine (9) photocopies of photometric reports for custom luminaires as follows:
 - a. Submit photometric reports when sample luminaires are submitted. Photometric reports shall be generated by testing the sample luminaire.
 - b. Photometric reports for custom luminaires shall be prepared by an independent testing laboratory.
3. Photometric testing and reporting shall conform to Illuminating Engineering Society (IES) LM 41 procedures and include: luminaire catalogue number, lamp type, ballast, ballast

factor, input watts, lumen distribution data, candela readings at 90, 45 and 0 degrees to the luminaire at 10 degree increments from 0 to 180 degrees vertical, candlepower distribution curves, lumen output data and spacing criteria.

THREE PLANES ARE LISTED FOR CANDELA READINGS.
THIS IS A MINIMUM VALUE FOR SYMMETRICAL
LUMINAIRES AND SHOULD BE MODIFIED AS NEEDED FOR
ASYMMETRICAL LUMINAIRES.

4. Submit independent laboratory test data for ballasts verifying compliance with specification requirements for project specific lamp/ballast combinations.

INCLUDE FOLLOWING SECTION IF SAMPLES ARE DESIRED.

1.06 SAMPLES

- A. Submit two (2) sample luminaires. Supply completely operable luminaires with specified lamp(s), and a six foot long cord and plug for standard 120 volt service. For 277 volt luminaires, provide 277/120 volt transformers if required by Contracting Officer. Provide component parts as specifically requested.
- B. Tag samples with project name, referenced specification, paragraph or drawing number, luminaire type number, and other identifying data. Ship one sample to Contracting Officer, and one sample to the address specified by Contracting Officer. After review, one sample shall be shipped to project site for reference use. Transportation charges for samples shall be paid by Contractor. Make luminaires identical with approved samples. Do not install any sample luminaires in the project.
- C. Unapproved samples shall be returned to Contractor at Contractor's expense. Upon receipt of sample disapproval, immediately submit new samples that meet contract requirements.

LIST SAMPLES TO BE PROVIDED BY CONTRACTOR

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Luminaires and their components shall be delivered to job site, factory-assembled and wired to the greatest extent practical, in strict accordance with approved shop drawings, samples, certificates and catalogue cuts, and shall be handled in a careful manner to avoid damage.
- B. Exposed finishes shall be protected during manufacture, transport, storage and handling. Delivered materials shall be identical to approved samples. Damaged materials shall be repaired and/or replaced as directed by Contracting Officer.
- C. Luminaires shall be stored under cover, above the ground, in clean, dry areas, and shall be tagged and/or marked as to type and location.

PART 2.0 - PRODUCTS

2.01 GENERAL

- A. Provide materials, equipment, appurtenances, and workmanship as specified and indicated on drawings. Make luminaire parts and components not specifically identified or indicated on the drawings, of materials most appropriate to their use or function, and resistant to corrosion and to thermal and mechanical stresses encountered in the normal application and function of the luminaires.
- B. Provide luminaires of sizes, types, and ratings indicated; complete with, but not necessarily limited to, housings, lamps, starters and wiring. Provide each luminaire with lamps as specified in work order. Specifications for luminaire components such as reflectors, lenses, lamps and ballasts shall be found elsewhere in this document.
- C. Provide recessed luminaires that are constructed to be suitable for and compatible with the ceiling, wall or pavement materials and construction in which they will be installed.
- D. Listed "Acceptable Manufacturers" represent adequate quality and reputation, and may supply products provided they certify compliance with specification requirements. Other standard products provided by that manufacturer are not automatically qualified. Unlisted manufacturers may be proposed only if they are of comparable quality, experience and reputation, and strictly adhere to the relevant specification requirements. See paragraph 1.04 B regarding Substitutions.

2.02 FLUORESCENT AND HID LUMINAIRES

EDIT THE FOLLOWING SUBSECTIONS TO REFLECT THE PROJECT DESIGN INTENT. DELETE THE SUBSECTIONS THAT ARE NOT APPLICABLE IN THEIR ENTIRETY.

A. General

- 1. Luminaires shall be provided with fluorescent lamps in the quantity, type, and wattage specified and compatible with ballasts.
- 2. Contractor shall verify whether luminaires require air return capability or are to be static.

WHEN EMI FILTERS ARE NEEDED INCLUDE THE FOLLOWING PARAGRAPH.

- 3. Fluorescent luminaires shall have electromagnetic interference filters. Filters shall either be integral or external to the ballast, but must be integral to luminaire assembly. Provide one filter per ballast that suppresses electromagnetic interference as required

by MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference."

4. Removal of Existing Luminaires:

Existing luminaires shall be removed as directed by scope of work. Proper disposal of components, including but not limited to ballasts containing PCBs, and lamps, shall be conducted according to relevant Federal, State, Local, and Agency regulations or guidelines. Contractor shall provide Contracting Officer with verification of proper disposal.

B. Descriptions

1. General:

- a. Luminaires shall meet UL 1570 or UL 1572 requirements, as applicable. The appropriate UL label or listing, or ETL Testing Laboratory label or listing, will be acceptable as evidence of compliance with UL requirements. Luminaires shall also comply with applicable National Electrical Code provisions, and with energy efficiency requirements as outlined below.
- b. Lamp Installation/removal shall be easily accomplished for all luminaires without tools. Attachments shall be secure and achieved with captive, non-removable fasteners. Fluorescent luminaires shall allow replacement of ballasts without removal of the luminaire or need for special tools.
- c. In fluorescent luminaires utilizing any form of electronic, solid state ballasts, fluorescent lampholders shall be of the "knife edge" type so long as "knife-edge" is available for the specific socket type. In all cases, supply the tightest fitting socket available. All elements of luminaire, lampholders, and connective wiring shall be tightly grounded.
- d. Provide luminaires which conform to the above standards and criteria, as indicated on the drawings, and as indicated below. Contractor shall verify ceiling conditions for all luminaire types.

LUMINAIRE, LAMP, AND BALLAST SPECIFICATIONS MUST BE DEVELOPED FOR EACH APPLICATION USING THE FOLLOWING FORMAT.

2. Interior Luminaire Data Format:

Luminaire Type "___":*(Description of Luminaire)*
Location:
Mounting: *(Recessed, surface, pendant)*
Housing: *(Nominal dimensions, material, finish)*
Reflector: *(Shape, material, finish, aperture distribution)*
Lamps: *(Quantity per luminaire or cross-section, type of lamp)*

Lamp Base: *(Type)*

Ballast: *(Voltage, type)*

Louver/Lens: *(Shape, dimensions, material, finish, performance characteristics)*

Trim and Hardware:

Other Features:

Photometric Performance: *(Lumen distribution or candela distribution)*

Coefficient of Utilization: *(Specify minimum CU for Room Cavity Ratio (RCR) of 1.0 and reflectances for ceiling, wall & floor)*

Spacing Criteria:

Maximum Luminance Ratio: *(If applicable)*

Acceptable Manufacturers: *(Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements)*

COMPLETE SPECIFICATIONS FOR LUMINAIRE COMPONENTS OUTLINED ABOVE ARE CONTAINED IN SECTIONS BELOW AND NEED TO BE REVIEWED AND EDITED FOR APPLICABILITY. IN ADDITION TO 2.02.A General AND 2.02.B Descriptions, THE FOLLOWING SECTIONS MAY BE RELEVANT WHEN RETROFITTING EXISTING LUMINAIRES: 2.02.C Marking of Luminaires, 2.02.E Luminaire Wiring, 2.02.F Lampholders and Supports, 2.02.J Aluminum Reflectors, and 2.02.K Specular Silver Reflectors.

C. Marking of Luminaires:

1. All luminaires shall be clearly marked for operation of specific lamps and ballasts and according to proper lamp type in accordance with UL 1570 or UL 1572 requirements, as applicable.
2. For maintenance purposes, the following lamp characteristics should be noted, as applicable, in the format "Use Lamps Only":
 - a Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - b Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
 - c Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
 - d ANSI ballast type (M98, M57, etc.) for HID luminaires.
 - e Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

3. All markings related to lamp type shall be clear and located to be readily visible to service personnel, but invisible from normal viewing angles when lamps are in place.
4. Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

D. Materials and Fabrication:

1. Unless otherwise noted, use only completely concealed hardware. Latching of luminaire door frames shall be unobtrusive. Make luminaire free from light leaks by the inherent design of the body and frame. Bond gaskets, when used, to the luminaire metal. Use bottom relamping unless otherwise noted.
2. Construct luminaires with the minimum number of joints. Make unexposed joints by approved method such as welding, brazing, screwing or bolting. Soldered joints are not acceptable.
3. Provide housings for luminaires that make electrical components easily accessible and replaceable, without removing the luminaire body from its mounting.

E. Luminaire Wiring:

1. Provide wiring between fluorescent lampholders and associated operating and starting equipment in compliance with UL 1570 and NEC.
2. Where there are two or more fluorescent lamps in a single luminaire, and multiple level control is indicated on specifications or drawings, multiple-lamp ballasts shall be used to the greatest extent possible and the following tandem wiring configurations shall apply:
 - a. A one-lamp electromagnetic ballast may be used only if there are an odd number of luminaires in the room, or if a luminaire is separated by more than 15 feet from any other luminaire with electromagnetic ballasts.
 - b. A one-lamp electronic ballast may be used if a luminaire with an electronic ballast is separated by more than 4 feet from any other luminaire with an electronic ballast, or if the nearest luminaire is on another control circuit. Otherwise, a lamp in one luminaire shall be tandem wired, that is, connected to a multi-lamp ballast in another luminaire.
 - c. If "inboard-outboard" wiring is specified for three-lamp luminaires, then the two outboard lamps shall be connected to a single two-lamp ballast within each luminaire. The inboard lamps of two adjacent luminaires shall be tandem wired, that is, connected to a two-lamp ballast within one luminaire.

F. Lampholders and Supports:

1. Provide fluorescent luminaire lampholders that are white, constructed of heat resistant plastic. Lampholders shall comply with UL 542 and ANSI C81.
2. When electronic solid state ballasts are called for in the luminaire description, lamp holders for 4'-0" lamps shall be of the knife edge variety so long as "knife-edge" is available for the specific socket type. In all cases, the lampholder providing the tightest electrical connection shall be used. Follow ballast manufacturer wiring instructions.
3. Lamp supports shall be used as recommended by lamp manufacturer.
4. Rigidly and securely attach lampholder to the luminaire enclosure.
5. Provide lampholders suitable for specified lamps, and position the lamps in optically correct spacing and relationship to lenses, reflectors, filters, and baffles.
6. Lampholder location shall provide properly located starting aid, as specified by the lamp manufacturer.

G. Finishes:

1. Unless otherwise specified, provide reflective surfaces with a white baked enamel finish, with a minimum reflectance of 86%. Prior to painting give all parts proper etched surface preparation to assure paint adherence and durability.

H. Lenses/Louvers/Trim:

1. All lenses and louvers shall be positively held within the door frames so that hinging or other motion of the frame will not cause the diffusing element to drop out.
2. For recessed luminaires with trim that is removable or open for access to the interior of the luminaire, and serves as a ceiling trim, provide trim that is positively held to the luminaire body by adjustable means that permit the trim to be drawn up to the ceiling as tight as necessary to insure complete contact of trim with ceiling surrounding the luminaire.

IF PRISMATIC LENSES ARE NOT SPECIFIED DELETE THE FOLLOWING AND ADD DESCRIPTION OF REQUIRED LENS.

3. Prismatic Lenses: Unless otherwise specified, prismatic lenses shall meet the following requirements:
 - a. Lens shall be made of clear virgin acrylic of nominal 0.125" overall thickness for nominal 2' x 4' pieces and 0.1875" nominal overall thickness for 3' x 3' pieces.

- b. Lens shall be composed of either 1/8" or 3/16" male or female prisms with non-curved prism faces. Female prism shall have a maximum depth of 0.053" for 1/8"; prisms and 0.080" for 3/16" prisms. Male prisms shall have a minimum unpenetrated thickness of 0.090" or thicker.
- c. Lens shall be a minimum of 7.5 oz. per square foot and show no visible evidence of sagging in the installed position.
- d. Lens shall be strain-free, uniform in appearance, and destaticized.
- e. Lens shall have minimum 80% visible transmittance.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- f. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

PARTS 2.02.I AND 2.02.J OF THIS SECTION REFER TO REFLECTOR MATERIALS USED AS INTEGRAL COMPONENTS IN NEW LUMINAIRE UNITS.

I. White Painted Reflectors and Shielding Media:

- 1. After forming, white painted material shall be free of any crazes or other deterioration that inhibit reflectivity or effect aesthetic appearance.
- 2. Material shall have an initial reflectance factor not less than 86% in the visible range of 400-700 nanometers per ASTM Method E-424-71 as determined by independent laboratory test of fading, tested in the following manner. One half of sample shall be covered and remaining half shall be exposed to a 150 watt sunlamp placed 1/2" above reflective surface for 72 hours. Comparison of exposed and unexposed sides shall show no visible fading or deterioration in appearance or reflectance.
- 3. The percentage of Specular Gloss shall be a minimum of 80% as determined by ASTM Method D-523-T, Procedure A.

J. Aluminum Reflectors and Shielding Media (Interior use, fluorescent luminaires):

- 1. Provide material no less than minimum thicknesses listed below for each application, or in accordance with the current UL standard 1570 for ballast covers, whichever is thicker. Material shall be absolutely free of tooling marks, spinning lines, and indentation marks caused by riveting or other assembly techniques. No rivets, springs or other hardware shall be visible after installation.

Cones	0.0500"
Wall wash kicker panels in cones	0.0400"
Reflectors (non-structural)	0.0200"
Louvers/Baffles	0.0200"

2. Other required aluminum reflectors and shielding media shall be formed and finished as noted on drawings and throughout specification. Material shall be free from blemishes, scratches, or indentations which would distort their reflective function.
3. Any aluminum reflector, cone, baffle, or louver utilized in whole or in part, within bottom two inches of luminaire, shall have low iridescent coating to reduce rainbow effect from rare earth phosphor lamps.
4. Anodized aluminum material shall have the following characteristics:

Type	Min. Weight of Coating (mg/in ²) <i>a</i>	Min. Total Hemispherical Reflectance <i>b</i>	Specular Component (min) <i>b</i>	Min. Visual	Max. Diffuseness Clarity <i>c</i>	at 15° <i>c</i>
Specular	2	86	70	90	0.03	
Specular (low iridescent)	5	85	46	80	0.05	
Semi-Specular (low iridescent)	5	82	10	35	0.40	

a. Anodizing process. Coating of aluminum oxide: Reference ASTM Test Method B-137.

b. Reference ASTM Test Method E-903-82 (testing utilizing a TR1 or TR2 Total Reflectometer is also acceptable pending issuance of ASTM standard).

c. Reference ASTM Test Method E-430-78 (1983).

5. Anodized aluminum reflectors of 86% or greater total hemispherical reflectance may be used for reflectors in new luminaires or for retrofit in existing luminaires as an exception to silver reflector film.

PARAGRAPH 2.02.K REFERS TO HIGHLY REFLECTIVE (>95%)
SPECULAR REFLECTORS PLACED INSIDE OF NEW OR EXISTING
LUMINAIRES. PARAGRAPH 2.02.K IS PRIMARILY INTENDED FOR
2X4 LUMINAIRE INSERTS.

K. Specular Silver Reflectors

1. General:
 - a. Reflector shall be comprised of unitized single piece construction for permanent mounting inside luminaire. A multi-piece reflector assembly shall only be considered if parts maintain fixed and accurate positioning in relation to lamps and housing, installation costs are not increased, and ballast access and luminaire maintenance is not compromised.
 - b. Design reflector expressly for lampholder positions, or relocate lampholder with permanent spacer plates to optimize the reflector photometric performance.

- c. Use captive hardware for securing removable reflector to housing.
- d. Use a minimum reflector thickness of 0.020 inch consisting of silver film laminated on aluminum or steel substrate, or high performance aluminum finish or multiple thin film coating.

IF REFLECTOR FILM IS USED INCLUDE THE NEXT TWO PARAGRAPHS.

- e. Use a minimum reflector film tensile strength of 45 lbs. per inch of width and a normal thickness of 0.0025 inch.
- f. Use a silver reflector film with front or back silver-coated construction on polyester film. Construction shall protect polyester film and adhesive from degradation due to ultraviolet light and humidity, and prevent silver from oxidizing or corroding.
- g. Material shall retain a minimum 93% specular reflectance, 96% image clarity, and 95% total reflectance for a minimum of 5 years, when cleaned as directed.
- h. Reflector shall be easily cleanable with a 2% liquid detergent in warm water and soft cloth. Such cleaning shall produce no signs of scratches or abrasions.
- I. Supply reflector static free to avoid attraction of airborne dust or dirt.
- j. Documentation from an independent testing laboratory shall be submitted verifying that the reflective material will not burn or emit toxic fumes under direct flame.

THE FOLLOWING PARAGRAPH SHOULD BE EDITED AS NEEDED DEPENDING ON THE REQUIREMENTS OF THE LUMINAIRE APPLICATION. THE FOLLOWING PARAGRAPH SHOULD BE INCLUDED WHERE GENERAL ILLUMINATION LUMINAIRES ARE BEING MODIFIED.

- k. Manufacturer will supply complete photometric information on distribution, efficiency, visual comfort, and coefficients of utilization from an independent testing lab for retrofit luminaire.
- l. Manufacturer will provide 10 year minimum product warranty including full product replacement and installation.

REFER TO TECHNICAL NOTES REGARDING SPACING CRITERIA, PARTIAL HEIGHT PARTITIONS AND DISTRIBUTION. THE FOLLOWING PARAGRAPH SHOULD BE INCLUDED WHERE GENERAL ILLUMINATION LUMINAIRES ARE BEING MODIFIED.

- m. The normal and parallel IES recommended spacing criteria of luminaires containing specular reflectors shall not be lower than actual spacing of luminaires,

divided by distance between height of work surface and the luminaire, in any areas.

- n. Illuminance distribution calculations, based on luminaires with specular reflectors, shall not exceed a maximum to minimum ratio of 1.5 to 1.0.

2. New Luminaires - Factory Installed:

- a. Luminaire shall be UL classified for use with reflector provided.
- b. Manufacturers will submit comparative photometrics by independent testing laboratories, showing identical luminaires with and without added reflector.

3. Specular Reflector Retrofits:

- a. Consult existing luminaire manufacturer for modification procedures which satisfy UL and other safety requirements.
- b. Contractor shall arrange for mockup, as specified below, for new products, product design, or variation in existing luminaire design, regardless of previous usage or mock-ups of such reflectors.
- c. Reflector shall be UL classified as a retrofit fluorescent luminaire component and shall be listed for use in each retrofitted luminaire or luminaire category.
- d. Reflector must be removable, without the need for tools, when access to the ballast is obstructed by the reflector. Reflector must be easily returned to the fixed optimal position, and secured without possibility for misalignment.
- e. When retrofitting a 4-lamp luminaire to a 2-lamp luminaire, lampholders shall be relocated in order to center lamps between outboard rails and the center ballast compartment.
- f. When retrofitting a 4-lamp luminaire to a 3-lamp luminaire, the lamps shall be equally spaced, with one lamp in the center, and the ballast compartment offset.
- g. Manufacturer will obtain original manufacturer's catalogue data, and shall be given one typical luminaire from Contracting Officer to perform test.
- h. Photometrics from independent test lab will demonstrate that the maximum allowable spacing of altered luminaire, as derived from IES spacing criteria, is greater than actual luminaire spacing in retrofitted area.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- i. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

FURTHER EXPLANATION OF THE FOLLOWING MOCKUP TESTING PROCEDURE IS CONTAINED IN THE TECHNICAL NOTES.

4. Mockups For Specular Retrofit Reflectors:

For each new manufacturer, reflector style, or luminaire, a mockup is required to establish overall effectiveness of retrofit reflectors. A minimum of 16 otherwise identical existing luminaires (20 preferred) shall be evaluated, half with retrofit reflectors and half without. The configuration of lamps and ballasts in both sets of luminaires will be established by Contracting Officer who will assess mockup performance, with the assistance of appropriate representatives for the facility, according to the following procedure:

- a. The Contracting Officer will select an area without daylight, where each set of 8-10 luminaires has similar relationships to work surfaces and wall surfaces. Room finishes and wall colors shall be the same for both sets of luminaires. Voltage, temperature and air movement shall be the same for both sets of luminaires. The first light readings shall be taken for a minimum of 14 locations.
- b. Thoroughly clean all surfaces of all 16 - 20 luminaires, including lenses. If ballasts are to be replaced, they must be replaced in all luminaires. All lamps shall be replaced with the same type and number of lamps per luminaire. If new lamps are used, they shall be operated for 100 hours prior to use in testing. The second set of light readings shall be taken for at least 14 locations.
- c. Install retrofit reflectors in half the cleaned and newly lamped luminaires, and reduce number of lamps to that proposed. The third set of light readings shall be taken for at least 14 locations.
- d. The Contracting Officer shall retain an independent lighting expert to evaluate aspects of quality and economics. The retrofit reflectors will be judged upon criteria which include, but are not limited to the following:
 - 1) Compliance with specifications.
 - 2) Ease of installation and required installation time per unit.
 - 3) Access to ballast and restoration of reflector to proper position.
 - 4) Illuminance and luminance; quantity, ratios, distribution.
 - 5) Luminaire appearance.
 - 6) Reflected patterns.
 - 7) Occupant response.
 - 8) The cost-effectiveness of the added reflector including efficiency, cost, and quality, as compared to alternative strategies.

2.03 FLUORESCENT LAMPS AND BALLASTS

A. BALLASTS

Contractor shall provide fluorescent ballasts for interior use that meet or exceed the following criteria:

1. General:
 - a. Provide energy efficient fluorescent ballasts conforming where relevant to UL 935, "Fluorescent-Lamp Ballasts," ANSI C82.1, "Ballasts for Fluorescent Lamps - Specification," ANSI C82.11, "High Frequency Fluorescent Lamp Ballasts," and ANSI C82.2 "Methods of Measurement of Fluorescent Lamp Ballasts," ANSI NFPA/70, and Public Law 100-357 National Appliance Energy Conservation Amendment of 1988, as applicable.
 - b. Unless otherwise specified, provide ballasts of same type and same manufacturer, for ease of stocking and replacement. Use multiple lamp ballasts to the greatest extent possible. See Section 2.02.E. for luminaire wiring.
 - c. Ballast shall be designed to operate on the voltage system to which they are connected, and designated by the ballast manufacturer as suitable and UL listed for operating the specified lamps.
 - d. Total Line Current Harmonic Distortion shall not exceed 20%.
 - e. Ballasts shall meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, Subpart C (RF Lighting Devices), regarding radio frequency interference (RFI) and electromagnetic interference (EMI).
 - f. Ballast shall be of high power factor type, with a power factor of 0.9 or greater.
 - g. Use Class P thermal protected.
 - h. Use sound rating "A" for all interior applications.
 - i. Ballast shall start lamps at a minimum starting temperature of 50° Fahrenheit for 40W T-12, T-8, and T-5 lamps and 60° Fahrenheit for 34W T-12 lamps. Provide low temperature fluorescent ballasts having a minimum starting temperature of 0° Fahrenheit in luminaires located where ambient temperature may fall below 50° Fahrenheit.
 - j. Ballasts shall withstand line transients as defined in ANSI/IEEE C62.41.
 - k. When specified for retrofit, ballast shall be appropriate for the physical dimensions of the luminaire's existing ballast cavity.

1. Ballast shall not contain polychlorinated biphenyls (PCBs) and shall be labeled "NO PCBs."
- o. Lamp current crest factor shall not exceed 1.7 when tested with 40 watt T-12 lamps, nor exceed 1.9 for 34 Watt T-12 lamps, as per ANSI C82-1 and C78.1. Lamp current crest factor shall not exceed 1.7 for all other lamp types
- p. Lamp/ballast efficacy factors shall meet or exceed the values shown in the table below.

SEE TECHNICAL NOTES FOR DESCRIPTION OF LAMP/BALLAST EFFICACY.

Fluorescent Lamp Efficiency Recommendation

Lamp Types	Recommended	Best
	Minimum Lumens	Available Lumens
Four-Foot Lamps:		
T8, 32 Watts	2800	3000
T12, 34 Watts	2800	2900
Eight-Foot Lamps:		
T8, 59 Watts	5700	5950
T12, 60 Watts	5600	6000
U-Tube Lamps:		
T8/U, 31 Watts	2600	2850
T12/U, 34 Watts	2700	2760

Ballast Efficiency Recommendation

Lamp Type	# of Lamps	Recommended BEF	Best Available
Four-Foot Lamps			
T-8, 32 Watts	1	2.54	2.96
	2	1.44	1.55
	3	0.93	1.00
	4	0.73	0.78
T-12, 34 Watts	1	2.64	3.05
	2	1.41	1.53
	3	0.93	0.95

2. Electromagnetic Energy Saving Ballast (ESB):

In addition to the requirements of 2.03.A.1., electromagnetic ballasts of the energy saving, "super low heat-rise" type shall meet or exceed the following criteria:

- a. Ballast shall meet all relevant ANSI specifications, and have CBM label.

INCLUDE THE FOLLOWING TEXT IF BALLASTS ARE FOR T-12 LAMPS.

- b. Energy saving ballasts designed for F40T12 rapid start lamps shall be compatible for use with both 40 watt and 34 watt lamps.

INCLUDE THE FOLLOWING TEXT IF BALLASTS ARE FOR T-12 LAMPS.

- c. Light output (ballast factor) shall be no less than 0.95 (± 0.025) when tested with 40 watt lamps and no less than 0.875 (± 0.025) when tested with 34 watt lamps.

INCLUDE THE FOLLOWING TEXT IF BALLASTS ARE FOR T-12 LAMPS AND DELETE ITEM e. BELOW.

- d. Ballasts shall have a warranty of three (3) years and a replacement labor allowance of \$10.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- e. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's certification of compliance with specification requirements).

SEE TECHNICAL NOTES FOR APPROPRIATE APPLICATION OF CATHODE CUT-OUT BALLASTS.

3. Electromagnetic Ballast with cathode cut-out (filament heat disconnect) feature:

In addition to the requirements of Section 2.03.A.1, cathode cut-out type ballasts shall meet the following criteria:

- a. Ballast shall have an electronic component which cuts off power to the lamp filaments of a rapid start lamp(s), once the lamp(s) has started.
- b. Cathode voltage for rapid start lamps during starting shall be between 3.4 and 4.5v across a dummy load per ANSI C.82.
- c. Light output (ballast factor) shall not be less than 0.81 for 40 watt lamps, nor less than 0.77 for 34 watt lamps.
- d. Ballast design shall provide full rated lamp life at three hours per start.
- e. Ballasts shall have a warranty of three (3) years and a replacement labor allowance of \$10.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING LIST.

- f. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements.)

4. Electronic (Solid State) Rapid Start Fluorescent Ballasts:

In addition to the requirements of 2.03.A.1., electronic rapid start ballasts shall meet or exceed the following criteria.

- a. Ballast shall meet all relevant ANSI specifications, and have CBM label.

THE FOLLOWING STATEMENT IS INCLUDED TO ASSURE THAT "FULL LIGHT OUTPUT" PRODUCTS ARE OBTAINED FOR FEMP Lights PROJECTS. HIGH AND LOW OUTPUT (BALLAST FACTOR) PRODUCTS ALSO ARE AVAILABLE AND CAN BE USEFUL IN COST-EFFECTIVELY REDUCING ENERGY USE. SEE THE TECHNICAL NOTES FOR A DISCUSSION OF APPLICATION ISSUES.

- b. Light output (ballast factor) shall be between 0.85 and 1.0 when tested with a compatible full-wattage lamp (40W T-12, T-8, OR T-5).
- c. Ballast shall be regulated to maintain light output which does not vary more than $\pm 5\%$ for all rapid start fluorescent lamps in the proper lamp/ballast combination within operating ranges of $\pm 10\%$ of center voltage. (Eg: 120 V or 277 V).
- d. Cathode voltage for rapid start lamps during starting shall be between 3.4 and 4.5v across a dummy load and between 2.5 and 4.4v during operation.
- e. Ballast shall have a frequency of operation of 20 KHz or greater and incorporate adequate 60 Hz filtering in order to operate with less than 5% flicker (maximum 0.20 Flicker Index) with any rare earth phosphor lamp suitable for the ballast.
- f. Ballasts shall have a warranty of five (5) years and a replacement labor allowance of \$10.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- g. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

5. Electronic (Solid State) Instant Start Fluorescent Ballasts:

In addition to the requirements of 2.03.A.1., electronic instant start ballasts shall meet or exceed the following criteria.

- a. Ballast shall meet all relevant ANSI specifications, and have CBM label.

THE FOLLOWING STATEMENT IS INCLUDED TO ASSURE THAT "FULL LIGHT OUTPUT" PRODUCTS ARE OBTAINED FOR FEMP Lights PROJECTS. HIGH AND LOW OUTPUT (BALLAST FACTOR) PRODUCTS ALSO ARE AVAILABLE AND CAN BE USEFUL IN COST-EFFECTIVELY REDUCING ENERGY USE. SEE THE TECHNICAL NOTES FOR A DISCUSSION OF APPLICATION ISSUES.

- b. Light output (ballast factor) shall be between 0.85 and 1.0 when tested with a compatible full-wattage lamp (40W T-12, T-8, OR T-5).
- c. Ballast shall be regulated to maintain light output which does not vary more than $\pm 5\%$ for all rapid start fluorescent lamps in the proper lamp/ballast combination within operating ranges of $\pm 10\%$ of center voltage. (Eg: 120 V or 277 V).
- d. Rated lamp life shall not be reduced more than 25% compared with rapid start operation, based on three hours per start.
- e. Ballast shall have a frequency of operation of 20 KHz or greater and incorporate adequate 60 Hz filtering in order to operate with less than 5% flicker (maximum 0.20 Flicker Index) with any rare earth phosphor lamp suitable for the ballast.
- f. Ballasts shall have a warranty of five (5) years and a replacement labor allowance of \$10.
- g. Multi-lamp ballasts shall operate lamps in parallel, so that when one lamp burns out the other lamps will continue operating at full light output.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- h. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

6. Electronic (Solid State) Dimming Ballasts

- a. Ballast shall be of high frequency solid state type with internal circuitry allowing continuous dimming from 100% to at least 20% light output in response to resistance on a low voltage circuit initiated by the ballast.
- b. Ballasts shall be regulated to maintain light output which does not vary more than $\pm 5\%$ for all rapid start fluorescent lamps in the proper lamp/ballast combination within operating ranges of $\pm 5\%$ of center voltage. (e.g., 120 V or 277 V).
- c. Ballasts shall have a frequency of operation of 20 KHz or greater and incorporate adequate 60 Hz filtering in order to operate with less than 5% flicker (maximum 0.20 Flicker Index) throughout the dimming range.
- d. Total Line Current Harmonic Distortion (THD) at full light output shall not exceed 20%. The absolute magnitude of THD shall not exceed this level throughout the dimming range.

THE FOLLOWING ITEM CAN BE MODIFIED IF OTHER LAMP TYPES ARE TO BE DIMMED.

- e. Ballasts shall have a warranty of five (5) years and a replacement labor allowance of \$10.
- f. Cathode voltage during starting shall be between 3.4 and 4.5v across a dummy load. All ballasts shall maintain full cathode voltage during operation throughout the dimming range.
- g. Ballasts shall be capable of starting with the lights dimmed in accordance with the controller/sensor setting.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- h. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

7. Compact Fluorescent Ballasts, Starters and Related Hardware

- a. In addition to the requirements of 2.03.A.1, compact fluorescent ballasts and related hardware shall comply with the following:
 - 1) The term "related hardware", as used in this specification section, refers to starters, thermal protection devices, and power factor correction devices, as applicable.

- 2) Ballasts and related hardware shall operate the specified lamps in accordance with ANSI C82.1 and C78, as applicable, and in accordance with the specified lamp manufacturer's recommendations where no ANSI standards exist.
- 3) Outdoor applications shall use Type I Outdoor rated ballasts.
- 4) Ballasts and related hardware for indoor use shall start lamps at a starting temperature of 50 degrees Fahrenheit.

SPECIFY MINIMUM STARTING TEMPERATURE IN THE NEXT PARAGRAPH.

- 5) For outdoors applications or where ambient temperatures may fall below 50 degrees Fahrenheit, manufacturers' minimum starting temperatures for both lamps and ballasts and related hardware shall be ____ degrees Fahrenheit.
- 6) Ballasts and related hardware shall withstand line transients as defined in IEEE publication 587, Category A.
- 7) Installation shall conform to applicable manufacturers' recommendations for enclosed or open operation of both lamps and ballasts, as applicable.

SECTION 2.03.A.7.b. DESCRIBES BALLASTS FOR HARD-WIRED RETROFITS AND NEW LUMINAIRES USING PRIMARILY LOWER WATTAGE (18 WATTS AND LOWER) COMPACT FLUORESCENT LAMPS, MOST OF WHICH HAVE INTEGRAL STARTERS. CORRESPONDING SPECIFICATION OF COMPACT FLUORESCENT LAMPS IS REQUIRED. SEE TECHNICAL NOTES FOR MORE INFORMATION.

b. Preheat Electromagnetic Ballasts for use with 2-pin Compact Fluorescent Lamps:

- 1) Ballasts shall comply with 2.03.A.7.a. General, above.
- 2) Ballasts shall be combined with lamp manufacturer's recommended starter (ignitor) if lamps do not have integral starters.
- 3) Ballasts shall be high power factor type or power factor corrected, with an effective Power Factor of 0.8 or greater.
- 4) Ballasts shall have a warranty of two (2) years and a replacement labor allowance of \$10.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 5) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

SECTIONS 2.03.A.7.c. AND 2.03.A.7.d. DESCRIBE ELECTROMAGNETIC AND ELECTRONIC BALLASTS FOR HARD-WIRED RETROFITS AND NEW LUMINAIRES USING PRIMARILY HIGHER WATTAGE (18 WATTS AND HIGHER) COMPACT FLUORESCENT LAMPS WITHOUT INTEGRAL STARTERS. CORRESPONDING SPECIFICATION OF COMPACT FLUORESCENT LAMPS IS REQUIRED. BALLASTS FOR RAPID START 22.5" AND 16.5" NOMINAL LENGTH T-5 LAMPS WITH 2G11 BASES SHOULD BE SPECIFIED USING SECTION 2.03.A.2. Electromagnetic Energy Saving, 2.03.A.4. Electronic Rapid Start, or 2.03.A.5. Electronic Instant Start. SEE TECH NOTES FOR MORE INFORMATION.

- c. Electromagnetic Rapid Start Ballasts for use with 4-pin Compact Fluorescent Lamps without Integral Starters:
 - 1) Ballasts shall comply with 2.03.A.7.a. General, above.
 - 2) In retrofit conversions, installation shall include a properly located starting aid, as specified by the lamp manufacturer.
 - 3) Ballasts shall be energy saving "super low heat-rise" type.
 - 4) Light output (ballast factor) shall be no less than 0.85 when tested with the lamps specified.
 - 5) Ballasts shall have a warranty of two (2) years and a replacement labor allowance of \$10.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 6) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements.)
- d. Electronic Rapid Start or Instant Start Ballasts for use with 4-pin Compact Fluorescent Lamps without Integral Starters:
 - 1) Ballasts shall comply with 2.03.A.7.a. General, above.
 - 2) Ballasts shall have a frequency of operation of 20 KHz or greater and incorporate adequate 60 Hz filtering in order to operate with less than 5% flicker (maximum 0.20 Flicker index) with any rare earth phosphor lamp suitable for the ballasts.

- 3) Ballasts shall be high power factor type, with a Power Factor of 0.9 or greater.
- 4) Ballasts shall have a warranty of five (5) years and a replacement labor allowance of \$10.

THE FOLLOWING STATEMENT IS INCLUDED TO ASSURE THAT "FULL LIGHT OUTPUT" PRODUCTS ARE OBTAINED FOR FEMP Lights PROJECTS. LOW OUTPUT (BALLAST FACTOR) PRODUCTS ALSO ARE AVAILABLE AND CAN BE USEFUL IN COST-EFFECTIVELY REDUCING ENERGY USE. SEE THE TECHNICAL NOTES FOR A DISCUSSION OF APPLICATION ISSUES.

- 5) Light output (ballast factor) shall be no less than 0.85 when tested with a compatible lamp.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 6) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements.)

8. Compact Fluorescent Lamp/Ballast Modular (Screw-In) Assemblies

a. General:

- 1) Modular assembly ballasts shall comply with the requirements of 2.03.A.1 and 2.03.A.7.a, above.
- 2) Modular assemblies, when combined with the specified lamps, shall fit appropriately into the existing socket, luminaire housing, reflector or lens.
- 3) Modular assemblies shall have a warranty of two (2) years.

SPECIFY MINIMUM STARTING TEMPERATURE IN THE FOLLOWING PARAGRAPH.

- 4) Installation shall conform to applicable manufacturers' recommendations for enclosed or open operation of both lamps and modular assemblies, as applicable.
- 5) The weight of the modular assemblies, including the specified lamp, shall not exceed the capacity of the existing socket, luminaire housing, or mounting system. The combined length of the modular assemblies, including the specified lamp, shall not exceed the physical dimensions of the luminaire housing.

SECTION 2.03.A.8.b DESCRIBES BALLASTS FOR SCREW-IN INCANDESCENT CONVERSIONS WHERE REPLACEABLE LAMPS ARE DESIRED. CORRESPONDING LAMP SPECIFICATION IS REQUIRED. SEE TECHNICAL NOTES FOR MORE INFORMATION.

b. Non-Integral (Removable Lamp) Modular Socket/Ballast Assemblies for Conversion of Incandescent to Compact Fluorescent Lamps:

- 1) Modular assemblies shall comply with 2.03.A.8.a General, above.
- 2) Modular assemblies shall be UL listed and consist of a compact fluorescent socket and ballast adapted for a medium screw base incandescent socket.
- 3) Modular assemblies shall be designed to operate the specified lamps and include appropriate starter (ignitor) if required.
- 4) The compact fluorescent sockets shall meet or exceed applicable ANSI standards and shall be rated for the lamp and base type specified, and the position of mounting in the retrofitted luminaire.
- 5) Lamps shall be replaceable without replacing the modular assembly.
- 6) Lamps shall comply with Compact Fluorescent Lamp requirements, below.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 7) Acceptable Manufacturers: List will be provided in final draft. Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements.

SECTION 2.03.A.8.c DESCRIBES BALLASTS FOR SCREW-IN INCANDESCENT CONVERSIONS WHERE NON-REPLACEABLE LAMPS ARE ACCEPTABLE. CORRESPONDING SPECIFICATION OF LAMPS IS NOT REQUIRED. BLANKS MUST BE FILLED IN FOR DESIRED SYSTEM. SEE TECH NOTES FOR MORE INFORMATION.

c. Integral (Non-Removable Lamp) Modular Socket/Ballast/Lamp Assemblies for Conversion of Incandescent to Compact Fluorescent Lamps:

- 1) Modular assemblies shall comply with 2.03.A.8.a General, above.
- 2) Modular assemblies shall be UL listed and consist of a compact fluorescent lamp and ballast adapted for a medium screw base socket.

- 3) Lamp section shall be thickly coated rare earth phosphor type with a correlated color temperature of 3000 Kelvin, and color rendering index (CRI) of 80 or greater (NEMA designation RE 830).
- 4) System lumen depreciation (LLD) shall result in a mean lumen value of at least 85% of initial lumen output at 40% of rated life.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 5) Acceptable Manufacturers: List will be provided in final draft. Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements.

B. LAMPS

1. General:

- a. Fluorescent and lamps shall meet or exceed the following criteria:
 - 1) Lamps shall conform to ANSI C78 where applicable data exists.
 - 2) Lamps shall utilize phosphors of a composition which includes rare earth phosphors, with a correlated color temperature (CCT) of 3500 Kelvin and a color rendering index (CRI) of not less than 70 CRI (NEMA designation RE 735).
 - 3) Provide new lamps in all cases, and replacement lamps in accordance with Paragraph 3.01.B. Field Quality Control.

a. 34 Watt, T-12 ("Energy Saving") Lamps:

SEE TECHNICAL NOTES FOR LIMITATIONS ON USES OF 34W T-12 LAMPS.

- 1) Lamp shall be rated at nominal 34 Watts.
- 2) Lamp shall be nominal T-12, 1-1/2" diameter tubes.
- 3) Initial rated lumen output shall be at least 2,800 lumens.
- 4) Rated lamp life shall be at least 20,000 hours, based on three-hour starts and tested in accordance with IES LM 40-87.
- 5) Lamp lumen depreciation (LLD) shall result in a mean lumen value of at least 2,460 lumens (88% of the initial lamp lumens) at 40% of rated life (8,000 hours)

and at least 2,295 lumens (82% of the initial lamp lumens) at 70% of rated life (14,000 hours).

- 6) Mortality curves at 3 operating hours per start shall show that less than 15% of lamps are burned out at 70% of rated life (14,000 hours).

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 7) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

b. T-8 Lamps:

- 1) Lamp shall be rated at nominal 32 Watts.
- 2) Lamp shall be nominal T-8, 1" diameter tubes.
- 3) Initial rated lumen output shall be at least 2,850 lumens.
- 4) Rated lamp life shall be at least 15,000 hours and 20,000 hours, per IES LM 40-87 operating on an instant start or rapid start mode, respectively.
- 5) Lamp lumen depreciation (LLD), shall result in a mean lumen value of at least 2,565 lumens (90% of the initial lamp lumens) at 40% of rated life (8,000 hours in rapid start mode or 6,000 hours in instant start mode) and at least 2,390 lumens (84% of the initial lamp lumens) at 70% of rated life (14,000 hours in rapid start mode or 10,500 hours in instant start mode).
- 6) Mortality curves at 3 operating hours per start shall show that less than 15% of lamps are burned out at 70% of rated life (14,000 hours in rapid start mode or 10,500 hours in instant start mode).

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 7) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

3. Rapid Start U-bent medium bipin or 2G11 base single-ended lamps:

a. T-12 U-Tube (Full Wattage) Lamps:

- 1) Lamp shall be rated at nominal 40 Watts, bent in a "U" shape with nominal 6" spacing between legs.
- 2) Lamp shall be nominal T-12, 1-1/2" diameter tubes.
- 3) Initial rated lumen output shall be at least 3,050 lumens.
- 4) Rated lamp life shall be at least 12,000 hours, based on three-hour starts and tested in accordance with IES LM 40-87.
- 5) Lamp lumen depreciation (LLD) shall result in a mean lumen value of at least 2,650 lumens (87% of the initial lamp lumens) at 40% of rated life (4,800 hours) and at least 2,470 lumens (81% of the initial lamp lumens) at 70% of rated life (8,400 hours).
- 6) Mortality curves at 3 operating hours per start shall show that less than 15% of lamps are burned out at 70% of rated life (8,400 hours).

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 7) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).
- b. T-8 U-Tube Lamps with nominal 1-5/8" leg spacing:
- 1) Lamp shall be T8, nominal 1" diameter tube, bent in a "U" shape, with two medium bipin bases, and a leg spacing of 1-5/8".
 - 2) Lamp shall be rated for a nominal 31 Watts input power.
 - 3) Initial lumen output shall be at least 2750 lumens.
 - 4) Rated lamp life shall be at least 20,000 hours, per IES LM 40-87, when operating in rapid start mode, or 15,000 hours when operating in rapid start mode.
 - 5) Lamp lumen depreciation (LLD) shall result in a mean lumen value of at least 2475 lumens (90% of the initial lamp lumens) at 40% of rated life (8,000 hours in rapid start mode or 6,000 hours in instant start mode) and at least 2310 lumens (84% of the initial lamp lumens) at 70% of rated life (14,000 hours in rapid start mode or 10,500 hours in instant start mode).
 - 6) Mortality curves shall show that less than 15% of lamps are burned out at 70% of rated life (14,000 hours in rapid start mode), at 3 operating hours per start.

- 7) Initial lumen output shall be at least 2750 lumens.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 8) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements.)

c. T-8 U-Tube Lamps with 6" leg spacing:

- 1) Lamp shall be T8, nominal 1" diameter tube, bent in a "U" shape, with two medium bipin bases, and a leg spacing of 6".
- 2) Lamp shall be rated for a nominal 31 Watts input power.
- 3) Initial lumen output shall be at least 2650 lumens.
- 4) Rated lamp life shall be at least 20,000 hours, per IES LM 40-87, when operating in rapid start mode, or 15,000 hours when operating in rapid start mode.
- 5) Lamp lumen depreciation (LLD) shall result in a mean lumen value of at least 2385 lumens (90% of the initial lamp lumens) at 40% of rated life (8,000 hours in rapid start mode or 6,000 hours in instant start mode) and at least 2226 lumens (84% of the initial lamp lumens) at 70% of rated life (14,000 hours in rapid start mode or 10,500 hours in instant start mode).
- 6) Mortality curves shall show that less than 15% of lamps are burned out at 70% of rated life (14,000 hours in rapid start mode), at 3 operating hours per start.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 7) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements.)

INCLUDE THE FOLLOWING TEXT FOR 22.5" NOMINAL LENGTH T-5 LAMPS WITH 2G11 BASES. OTHER T-5 LAMPS SHOULD BE SPECIFIED USING SECTION 2.03.B.4. COMPACT FLUORESCENT LAMPS. SEE TECH NOTES FOR MORE INFORMATION ON NEMA GENERIC DESIGNATION OF THESE LAMPS.

d. T-5 Twin-Tube 22.5" Lamps (NEMA designation "FT" (Fluorescent Twin):

- 1) Lamp shall be rated at nominal 38 to 40 Watts, single-ended with a 2G11 base.
- 2) Lamp shall be nominal T-5, 5/8" diameter tubes with a total nominal length of 22.5".
- 3) Initial rated lumen output shall be at least 3150 lumens.
- 4) Rated lamp life shall be at least 15,000 or 20,000 hours based on three-hour starts, and tested per IES LM 40-87 in instant start or rapid start mode, respectively.
- 5) Lamp lumen depreciation (LLD) shall result in a mean lumen value of at least 2772 lumens (88 % of the initial lamp lumens) at 40% of rated life (8000 hours) and at least 2598 lumens (82.5% of the initial lamp lumens) at 70% of rated life (14,000 hours).
- 6) Mortality curves at 3 operating hours per start shall show that less than 15% of lamps are burned out at 70% of rated life (14,000 hours).

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- 7) Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

4. Compact Fluorescent

a. General:

- 1) Lamps shall utilize phosphors of a composition which includes rare earth phosphors, with a correlated color temperature (CCT) of 3000 Kelvin and a color rendering index (CRI) of not less than 80 CRI (NEMA designation RE 830).
- 2) Lamp lumen depreciation (LLD) shall result in a mean lumen value of at least 85% of initial lamp lumens at 40% of rated life.
- 3) Installation shall conform to applicable manufacturers' recommendations for enclosed or open operation of both lamps and ballasts.
- 4) For outdoors applications or where ambient temperatures may fall below 50 degrees Fahrenheit, manufacturers' minimum starting temperatures for lamps shall be ____ degrees Fahrenheit.

2.04 HID LAMPS AND BALLASTS

A. BALLASTS, CAPACITORS, AND STARTERS

HID ballasts with appropriate capacitors and starter, referred to herein as the ballast assemblies, shall meet or exceed the following criteria:

1. HID ballast assemblies shall conform to all relevant UL, ANSI, and ANSI/NFPA listings, standards, and codes. Ballasts shall be UL 1029 and 1572 listed and meet ANSI C82.4.
2. Unless otherwise specified, ballast assemblies for each lamp type shall be of the same type and same manufacturer, for ease of stocking and replacement.
3. Ballast assemblies shall be designed to operate at the specified voltage, and designated by the ballast manufacturer as suitable and UL listed for operating the specified lamps.
4. Lamp current crest factor shall not exceed 1.8.
5. Ballast assemblies shall be capable of starting and operating the specified lamps within a range of $\pm 10\%$ of the specified voltage.
6. Total Line Current Harmonic Distortion shall not exceed 35%.
7. Electronic ballast assemblies shall meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, Subpart C (RF Lighting Devices), regarding radio frequency interference (RFI) and electromagnetic interference (EMI).
8. Ballast shall be of high power factor or power factor corrected type, with a power factor of 0.9 or greater.
9. Insulation shall be Class 180 degree C minimum.
10. Ballast assemblies shall start lamps at a minimum temperature of -20° Fahrenheit.
11. Ballast assemblies shall withstand line transients as defined in ANSI/C62.41.
12. When specified for retrofit, ballast assemblies shall be appropriate for the physical dimensions of the luminaire's existing ballast cavity.

THE FOLLOWING WARRANTY PERIOD SHOULD BE DETERMINED BY THE USER AGENCY FOR EACH BALLAST TYPE SPECIFIED.

13. Ballast shall have a warranty of two (2) years and a replacement labor allowance of \$10.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST

OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

14. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's certification of compliance with specification requirements).

B. HID LAMPS

HID lamps shall meet or exceed the following criteria.

1. Lamps provided shall conform to ANSI C78 where applicable data exists.
2. Provide new lamps in all cases, and replacement lamps in accordance with Paragraph 3.01.B. Field Quality Control.
3. Lamps shall be designed for operation with the specified ballast assembly.
4. Lamp shall be designed for operation in the specified mounting position.

ONE OF THE FOLLOWING TWO ITEMS CAN BE KEPT IF INSTANT RESTRIKE FEATURES ARE NEEDED AND INCANDESCENT BACKUP IS NOT SPECIFIED FOR LUMINAIRES. NOTE THE SECOND ITEM REQUIRES AN IGNITOR TO BE SPECIFIED WITH THE FIXTURES.

5. Lamps shall have two arc tubes so that instant restrike will occur in the event of a momentary power failure.
6. Lamps will include a lead for a high voltage ignitor to allow instant restrike to occur in the event of a momentary power failure.
7. Lamps shall be clear or coated, as specified, or as required for proper luminaire performance.
8. Lamp shall have the highest CRI available at the specified color temperature. If color temperature is not clearly specified, consult Contracting Officer for clarification.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

9. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

2.05 FLUORESCENT DIMMING CONTROLS

SECTION 2.05 ALLOWS THE SPECIFICATION OF DIMMING FLUORESCENT BALLASTS WITH PHOTOCCELL, OCCUPANCY SENSOR, AND/OR OTHER DIMMING CONTROLS. THE SPECIFICATION MUST BE DEVELOPED IN CONJUNCTION WITH DRAWINGS SHOWING BALLAST, SENSOR, AND CONTROLLER LOCATIONS AS WELL AS THE RELATIONSHIP BETWEEN SENSORS, BALLASTS, AND CONTROLLERS.

IN GENERAL, CERTIFIED COMPATIBILITY BETWEEN BALLAST, SENSOR, AND CONTROLLER IS USED IN LIEU OF SPECIFICATION LANGUAGE THAT IS REDUNDANT OR POTENTIALLY CONFLICTING WITH MANUFACTURERS' COMPATIBILITY PROTOCOL. AN EXCEPTION IS THE LANGUAGE FOR CONTROL VIA MORE GENERIC DIRECT DIGITAL CONTROLS (DDC), WHICH CAN BE ACHIEVED USING SENSORS AND CONTROLLERS THAT MAY NOT HAVE BEEN MANUFACTURED SPECIFICALLY FOR USE WITH DIMMING BALLASTS.

SEE TECHNICAL NOTES FOR MORE INFORMATION.

A. General

Provide, install, and place into operation all components, in combination and calibrated to effectively achieve automatic control of fluorescent lights.

1. All components specified in this section shall be compatible for the control functions specified, as certified by the contractor and component manufacturers.
2. The completed control system shall conform with the conditions of UL listing for each of the components used in the system.
3. The wiring of the control system and all of its components shall meet manufacturers' recommendations and shall be in accordance with the National Electrical Code and all local electrical codes, as applicable.
4. All components shall be separately and individually connected to an appropriate path to ground.
5. Class 2, low voltage wiring shall be #18 AWG, and run between control system components as a twisted pair. Class 2 wiring runs shall be isolated from line voltage wiring. Shielded cable or conduit shall be used as recommended by manufacturers.
6. Wiring run lengths between control system components shall not exceed manufacturers' recommendations.
7. Wiring runs shall be mounted in such a manner that the wire will not be damaged as a result standard building use and maintenance functions.

THE FOLLOWING SECTIONS SHOULD BE EDITED BASED ON INTENDED CONTROL SYSTEM FUNCTIONALITY.

8. The control system shall use photocell sensors to monitor and adjust ballast light output so as to maintain a field-set target footcandle level on work surfaces. Dimming shall occur in response to daylight contribution or lighting system output that causes photocell sensor readings to exceed those set during calibration.

INCLUDE THE FOLLOWING ITEM IF A DELAY IS DESIRED TO SMOOTH PHOTOCELL CONTROLLED DIMMING IN APPLICATIONS WHERE FREQUENT AMBIENT LIGHT VARIATIONS ARE ANTICIPATED. THIS DELAY MAY BE BUILT INTO THE PHOTOCELL SENSOR, THE BALLAST, OR THE CONTROLLER AND MAY ALSO MAY BE ADJUSTABLE DEPENDING ON MANUFACTURER.

9. Control system shall include a delay of ____ seconds between photocell sensor input and ballast dimming response.

INCLUDE THE FOLLOWING ITEM IF MORE COMPLEX CONTROL PROTOCOL IS USED TO SWITCH BALLASTS OFF TO SAVE ADDITIONAL ENERGY.

10. The control system shall switch the lights off if a field-set photocell sensor level and period of time at a fully dimmed setting have been exceeded. Lights should be switched on when photocell sensor indicates that light levels have dropped below the field-set target.
11. The control system shall use occupancy sensors to fully dim ballasts when no occupants are sensed in the controlled space. Occupancy sensor control of ballasts shall override photocell sensor control of ballasts.

INCLUDE THE FOLLOWING IF MANUAL WALL SWITCHES OR ON/OFF OCCUPANT SENSOR CONTROLS ARE TO BE USED.

B. Electronic (Solid State) Fluorescent Dimming Ballasts

1. Electronic Fluorescent Dimming Ballasts shall comply with 2.03.A.6.
2. Electronic Fluorescent Dimming Ballasts shall meet all applicable UL listings for the applications specified herein.
3. Ballasts shall start lamps at a dimmed setting as appropriate based on control system operation.

C. Controllers for Electronic Dimming Ballasts

Contractor shall provide ballast controllers as shown on the drawings and in the quantities indicated that meet or exceed the following criteria:

1. Controllers shall meet all applicable UL listings for the applications specified herein.

THE FOLLOWING TWO ITEMS ARE FOR CONTROLLERS MANUFACTURED FOR AND DEDICATED TO THE CONTROL OF DIMMING BALLASTS.

2. Controllers shall be specifically designed and manufactured for operation with the ballasts and sensors specified herein and shall be capable of achieving, in combination with the ballasts and controllers, all aspects of the specified control system functionality.
3. Controllers shall be wired as shown on drawings and control no more than the maximum number of ballasts recommended by the manufacturer.

THE REMAINING ITEMS ARE MORE SPECIFIC REGARDING THE INTERFACE BETWEEN BALLAST AND CONTROLLER, AND ARE INTENDED FOR USE WITHIN A GENERIC DIRECT DIGITAL CONTROLS (DDC) SPECIFICATION WHERE THE CONTROLLER HAS A VARIETY OF FUNCTIONS AND/OR IS NOT MANUFACTURED SPECIFICALLY FOR USE WITH THE BALLASTS AND SENSORS. VOLTAGE AND AMPERAGE REFERENCES SHOULD BE CHECKED WITH SPECIFIC MANUFACTURERS FOR APPLICABILITY.

4. The control device shall be capable of accepting or sinking the DC current flow from the ballast. The maximum and minimum DC current from the ballast that must be sunk by the control circuit is a function of the applied control voltage. The maximum under any condition is 500 microamps per ballast, with multiple ballasts connected in parallel on any one control circuit.
5. The length of the control bus, the wire size of the bus, and the number of ballasts connected on the bus shall be configured so that the DC voltage drop as a function of the resistance of the wire and the control current flowing does not exceed 0.2 volts.
6. If the control bus is opened or if the control device internally opens the control bus under some condition, the voltage on the control bus will then be a function of the ballasts which is 10 volts, ± 0.5 volts. Maximum light output will be delivered under this condition.
7. If the control bus is shorted either by a mechanical switch in the control or by the circuitry of the control device inadvertently in the wiring, the current on the control bus will be 500 microamps per ballast maximum. All ballasts on the control bus will then operate at minimum light levels.
8. The control equipment must not impose a voltage greater than 11.0 volts maximum on the ballast control leads.
9. The DC control voltage should have a maximum peak-to-peak ripple (low and high frequency ripple) not exceeding 10% of the average DC voltage. Short-term transient voltage of the control devices must not exceed 14 volts.
10. The control equipment intended to control more than one ballast must be capable of sinking the current supplied to the control bus by the maximum number of ballasts

specified for the control device. At any given level setting, it must maintain control bus voltage constant within a range of $\pm 5\%$ as the number of ballasts connected to the control bus varies from a minimum of one ballast up to the maximum number specified for the control device.

11. All control devices that are connected to the power line must have proper isolation between the power line and the control leads. Any control devices that are connected to the power line must have UL approval/recognition as Class II equipment.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

12. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

D. Photocell Sensors

Contractor shall provide photocell sensors as shown on the drawings and in the quantities indicated that meet or exceed the following criteria:

1. Photocell sensors shall meet all applicable UL listings for the applications specified herein.

USE THE FOLLOWING TWO ITEMS IF PHOTOCCELL SENSORS CONTROL THE BALLASTS DIRECTLY.

2. The number of ballasts controlled by a single photocell sensor shall not exceed the maximum recommended by the photocell sensor manufacturer.
3. Photocell sensors shall be specifically designed to operate dimming ballasts through a range of foot candles appropriate for the application specified herein.

THE FIRST SENTENCE OF THE FOLLOWING ITEM CAN BE MODIFIED LESS FOR COMMON OUTDOOR SENSOR LOCATION. OTHER CRITERIA STILL APPLY.

4. Photocell sensors shall be ceiling mounted and facing down toward work surfaces. The photocells shall be installed away from sources of strong or concentrated light and should never be in direct sunlight. Mounting should allow for relocation by the contractor during calibration in order to achieve proper system operation.

CONE OF RESPONSE WILL VARY BASED ON THE APPLICATION. IF SEVERAL DAYLIGHTING CONFIGURATIONS ARE BEING SPECIFIED, THIS ITEM SHOULD BE MOVED TO THE DRAWINGS AND CROSS REFERENCED HERE.

6. Photocell sensors shall have a _____ degree cone of response.
7. The photocell sensors shall measure illuminance as related to the CIE Standard Observer Curve. Photocell sensors shall measure visible light with a sensor having spectral responsivity curve equal to the average human eye.

DELETE THE FOLLOWING ITEM IF RESPONSE DELAY IS DESIRED AND
BUILT INTO PHOTOCELL SENSOR.

8. Photocell sensor response time shall not exceed 10 microseconds.
9. Absolute calibration of photocell sensors shall be $\pm 5\%$ traceable to National Institute of Standards and Technology (NIST).
10. Contractor shall provide voltage-to-footcandle curve for the entire range of photocell sensor operation.
11. Response stability over time shall be within a $\pm 2\%$ range over a one year period.
12. Response variation with temperature shall not exceed $\pm 0.15\%$ per degree C maximum.
13. Sensor shall be cosine corrected up to 80 degree angle of incidence or throughout the cone of response if it is less than 160 degrees.
14. Sensor response shall have less than $\pm 1\%$ error over 360 degrees at 45 degrees elevation.
15. Operating environment shall be at least 20 to 65 degrees C and 0 to 100% relative humidity.
16. Housing shall be appropriate for indoor use and protected from abuse.
17. Photocell sensors shall be supplied complete with all mounting hardware as required.
18. When installed in 2X2 ceiling tiles, each photocell sensor shall be installed with 5' of slack wiring coiled in the ceiling cavity, so that sensors can be relocated without rewiring.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF
MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION
REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE
MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

19. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

E. Occupancy Sensors

1. Occupancy Sensors shall comply with 2.06 Occupancy Sensors.

2. Occupancy sensors shall meet all applicable UL listings for the applications specified herein.

USE THE FOLLOWING TWO ITEMS IF OCCUPANCY SENSORS CONTROL THE BALLASTS DIRECTLY.

3. The number of ballasts controlled by a single occupancy sensor shall not exceed the maximum recommended by the occupancy sensor manufacturer.
4. Occupancy sensors shall be specifically designed to operate dimming ballasts in a manner which results in fully dimmed ballast operation during unoccupied periods and full-output ballast operation when occupants are present.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

5. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

F. Calibration of Photocell Dimming Controls

Calibration shall be performed for each photocell sensor control by the Contractor prior to system turnover and rechecked or recalibrated three months later (or as recommended by ballast, photocell sensor, and controller manufacturers). Contractor shall first arrange for and receive on-site training by a representative of the ballast or controller manufacturer in spaces representing the range of dimming applications and configurations on the project. Both the training and the control calibration shall include the system designer and appropriate maintenance personnel from the building operations staff.

1. Specific instructions for calibration shall be provided as part of the O&M manual (See Section 3.05) representing the range of applications on the project.
2. Calibration shall be done at least one week after and no more than one month after occupants have moved into the space.
3. Calibration shall be performed during non-daylight hours using a hand-held light meter with an accuracy of at least $\pm 5\%$ in the footcandle range being measured.
4. The HVAC system shall be enabled and space temperatures shall have been at the occupied setpoint for at least eight hours prior to calibration.
5. The lighting system being controlled shall be operated for at least one hour immediately prior to calibration and for at least 100 hours in total.

CONSIDER MOVING TARGET FOOTCANDLE INFORMATION TO DRAWINGS IF SEVERAL TARGETS ARE TO BE SPECIFIED.

6. Within each controlled zone, controls shall be adjusted so that at least ____ footcandles are measured using a hand-held light meter on each work surface within that zone. To accomplish this, the work surface with the lowest measurement shall be identified and used as the basis for setting controls to the target light level. Work surfaces where the target footcandle level cannot be achieved even at full light output should be pointed out to the system designer and building operations representative during calibration.

THE FOLLOWING ITEMS CAN BE USED IF BALLASTS ARE TO BE SWITCHED OFF WHEN ADEQUATE DAYLIGHT HAS BEEN PRESENT FOR A SIGNIFICANT PERIOD OF TIME. THIS REQUIRES A PROGRAMMABLE DDC CONTROLLER. THE 10% RANGE AND 15 MINUTE DIMMED THRESHOLDS CAN BE ADJUSTED BASED ON DAY LIGHTING CONFIGURATION AND PERFORMANCE.

7. Record the output voltage of the photocell sensor with the controls set to meet the target footcandle level. Using the voltage-to-footcandle curve for the photocell sensor, determine the footcandle value on the curve corresponding to this photocell sensor output level. Note that it is unlikely that the curve value and the target footcandle value will be the same or even close.
8. Adjust the ballasts to their fully dimmed setting. Use the hand-held meter to take a dimmed footcandle reading at the same workstation used for setting controls to meet target footcandle levels.
9. Add the fully dimmed footcandle reading to the footcandle value taken from the sensor curve. Multiply this sum by 1.1 and find the voltage on the sensor curve that corresponds to this footcandle value.
10. Program the control system to turn lights off if ballasts have been fully dimmed for 15 minutes and photocell sensor output corresponds to the voltage calculated in the previous item. Ballast should be turned on when the photocell sensor output drops below the setting for target foot candles.

THE FOLLOWING SPECIFICATION IS PROVIDED FOR THOSE FACILITIES DESIRING A "HANDS-ON" APPLICATION AND MAINTENANCE OF LIGHTING CONTROL SYSTEMS. DELETE IF NOT NEEDED OR DESIRED.

G. Light Meter

One hand-held, portable, illuminance meter shall be supplied as follows:

1. Meter shall be capable of measuring foot candles or lux in a range from 0 to 5 000 foot candles and 50 000 lux.
2. Meter shall be battery operated.

3. The sensor shall measure illuminance as related to the CIE Standard Observer Curve. Sensors shall measure visible light with a sensor having spectral responsivity curve equal to the average human eye.
4. Display response time shall not exceed 0.5 seconds.
5. Absolute calibration of the sensor shall be $\pm 5\%$ traceable to National Institute of Standards and Technology (NIST).
6. Response stability over time shall be within a $\pm 2\%$ range over a one year period.
7. Response variation with temperature shall not exceed $\pm 0.15\%$ per degree C maximum.
8. Sensor shall be cosine corrected up to 80 degree angle of incidence.
9. Sensor response shall have less than $\pm 1\%$ error over 360 degrees at 45 degrees elevation.
10. Operating environment shall be at least 20 to 50 degrees C and 0 to 80% relative humidity.
11. Meter shall include case for carrying and storage.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

12. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

2.06 OCCUPANCY SENSORS

A. GENERAL

1. Manufacturer gross rated area of coverage shall not be used as an indication of sensor coverage in a specific application. Coverage patterns shall be derated as recommended by manufacturer based on mounting height of sensor, furniture and partition locations, and finish of interior surfaces. Sensors shall be able to detect typical motion (e.g. walking in corridors; writing and computer use in offices) throughout the accessible portions of spaces lighted by controlled luminaires.
2. Provide manufacturer with drawings showing all sensor locations and types, as well as furniture locations, for all areas where occupancy sensors will be installed. Verify sensor layouts and aiming with manufacturer prior to ordering any sensors.
3. All sensors, control units, transformers, power packs, switchpacks, and relays shall:
 - a. Be UL listed under Section 508 - Industrial Control Equipment.

- b. Conform to all applicable portions of the National Electric Code.
 - c. Be rated for operation in ambient air temperatures ranging from 50°F (10°C) to 104°F (40°C) when installed in conditioned spaces. When used in locations where ambient air temperatures may fall below 50°F (10°C), provide equipment rated for operation in ambient air temperatures ranging from -40°F (-40°C) to 95°F (35°C).
 - d. Have a manufacturer's replacement warranty of five (5) years or longer.
 - e. Be fabricated by a manufacturer that has been continuously manufacturing occupancy sensors for at least five (5) years.
- 4. All switching devices shall employ zero-crossing switching technology, or be otherwise designed to withstand the high inrush current caused by electronic ballasts. If not clearly indicated on submittals, the manufacturer must provide data that substantiates compliance with this requirement.
 - 5. All visible components shall be finished in NEMA standard colors.
 - 6. Contracting Officer shall be free to choose between all standard colors offered by manufacturer for all visible components.
 - 7. All sensors shall be approved by the California Energy Commission.

B. CEILING-MOUNTED ULTRASONIC OCCUPANCY SENSORS

In addition to the requirements of Paragraph A, above, ceiling-mounted ultrasonic occupancy sensors shall meet or exceed the following criteria:

- 1. Sensors shall be mounted flat against the ceiling, in locations shown on the Electrical Drawings or required by field conditions. Do not install sensors in locations where air blows across them, or where their view of the area they are controlling is obstructed by dropped beams, soffits, or other irregular ceiling conditions. Maintain a minimum 72" separation between sensors and HVAC supply diffusers.
- 2. When sensors located in adjacent lighting control zones have overlapping coverage areas, provide sensors which are designed in such a way that they do not interfere with one another.
- 3. Sensor shall be entirely low-voltage (nominal 15V-24V), NEC Class 2 device, which is powered by, and sends switching signals back to, power pack(s) (see paragraph C, below). Provide 72" slack in the cable connecting each sensor with its power pack to allow for sensor relocation.
- 4. Sensor shall detect motion by emitting high frequency (nominal 25kHz-40kHz) audio signals, and listening for a Doppler shift in the return signal. Sensor shall not emit any

audible sound, and shall be designed in such a way that it does not interfere with properly operating hearing aids.

5. Sensor shall be entirely solid-state, crystal controlled to within $\pm 0.005\%$ frequency variation.
6. Sensor shall have an LED, clearly visible throughout coverage range, which flashes each time motion is detected.
7. Sensor shall have a concealed override switch or other provision which allows maintenance personnel to easily bypass the sensor in case of malfunction. Bypassing the sensor shall result in a continuous "on" signal being sent to connected power pack(s), so that the lights remain on.
8. Time delay (after motion is no longer detected before lights are turned out) shall be adjustable through a range including at least 30 seconds to 15 minutes. Adjustment mechanism shall be located in sensor.
9. Sensitivity to motion shall be adjustable. Adjustment mechanism shall be located in sensor.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

10. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

C. POWER PACKS FOR USE IN CONJUNCTION WITH CEILING-MOUNTED OCCUPANCY SENSORS

1. Power packs are intended for use in conjunction with ceiling-mounted occupancy sensors. In addition to the requirements of Paragraph A, above, power packs shall meet or exceed the following criteria:
2. Provide power packs in quantities shown on the Electrical Drawings, or required by field conditions or manufacturer's recommendations.
3. Designated constant-burn or emergency luminaires shall never be controlled by power packs.
4. Power packs shall provide NEC Class 2 low voltage (nominal 15V-24V) power to ceiling-mounted occupancy sensors.
5. Power packs shall switch line voltage lighting loads on and off in response to signals received from the ceiling-mounted occupancy sensors. Power packs shall have no minimum load requirement.

6. Each power pack shall be capable of powering, and receiving control signals from, multiple occupancy sensors. Provide 72" slack in the cable connecting each sensor with its power pack to allow for sensor relocation.
7. Multiple power packs shall be capable of working together in a master/slave arrangement to control multiple circuits together.
8. Power packs shall shield all sensors they power from the effects of inrush current.
9. Acceptable manufacturers: Power packs shall be provided by the manufacturer of the sensors to which they are connected.

D. SENTRY SWITCHES FOR USE IN CONJUNCTION WITH CEILING-MOUNTED OCCUPANCY SENSORS AND POWER PACKS

Sentry switches are intended for use in conjunction with ceiling-mounted occupancy sensors and power packs to make the ceiling-mounted sensors function in a manual-on, automatic-off mode.

In addition to the requirements of Paragraph A, above, sentry switches shall meet or exceed the following criteria:

1. Provide sentry switches in locations indicated on the Electrical Drawings, wall-mounted at standard switch height in compliance with Americans with Disabilities Act Guidelines. Wire sentry switches in series between the power packs and the loads controlled by the power packs. Where three-way switching is required, wire sentry switches in parallel with each other, or as recommended by manufacturer.
2. A sentry switch is a toggle switch with an "on" (up) and "off" (down) position. When the switch is in the "off" position, it will remain in that position until manually moved into the "on" position. When the switch is in the "on" position remain in that position until manually moved into the "off" position, **or until the power coming to the switch from the power pack is shut off**. When the power coming to the switch is shut off, the switch will automatically reset to the "off" position after a time delay of 10 seconds. If power to the switch is restored before the end of the 10 second time delay, the switch will remain in the "on" position.
3. The switch shall operate silently.
4. Acceptable manufacturers: Sentry switches shall be provided by the manufacturer of the power packs they are connected to.

E. WALL-MOUNTED OCCUPANCY SENSORS

Wall-mounted occupancy sensors are intended for use in **small rooms with no interior obstructions**. In addition to the requirements of Paragraph A, above, wall-mounted occupancy sensors shall meet or exceed the following criteria:

1. Sensors shall be wall-mounted at standard switch height in compliance with Americans with Disabilities Act Guidelines. Locate sensors as shown on the Electrical Drawings, as required by field conditions, or as directed by the Architect. Do not install sensors in locations where their view of the space they are controlling will be obstructed by doors or furniture. Provide special three-way switches where required and wire as per manufacturer's recommendations.
2. Sensor shall be designed to fit in standard single-gang switchbox. Mount in multigang box when adjacent to other switches.
3. Faceplate shall have no visible hardware, and shall be Leviton Decora-Plus type unless otherwise specified.
4. Designated constant-burn or emergency luminaires shall never be controlled by occupancy sensors.
5. Sensor shall incorporate a motion detector and a manual tap switch to operate lights in manual-on, automatic-off mode only.
6. Sensor shall detect motion through one of two methods:
 - a. **Ultrasonic:** by emitting high frequency (nominal 25kHz-40kHz) audio signals, and listening for a Doppler shift in the return signal. Ultrasonic sensors shall not emit any audible sound, and shall be designed in such a way that they do not interfere with properly operating hearing aids. Ultrasonic sensors shall be entirely solid-state, crystal controlled to within $\pm 0.005\%$ frequency variation. Ultrasonic sensors shall have separate controls for "entry sensitivity" (sensitivity to motion near the sensor) and "area sensitivity" (sensitivity to motion away from the sensor).
 - b. **Passive Infrared:** By passively sensing changes in the infrared radiation received by the sensor from various zones in the room. Passive infrared sensors shall be entirely solid-state, and shall have a fresnel lens with no less than two vertical levels to break up the room into different zones for IR detection, assuring hand motion coverage. Passive infrared sensors shall have a full 180° field of view in the horizontal plane when not "masked".
7. Sensor shall have an LED, clearly visible throughout coverage range, which flashes each time motion is detected.
8. Sensor shall have a concealed override switch or other provision which allows maintenance personnel to easily bypass the motion detector in case of malfunction. Bypassing the motion detector shall cause the device to operate like a standard wall switch. Sensors with override switches that are not concealed are unacceptable.
9. Time delay (after motion is no longer detected before lights are turned out) shall be adjustable through a range including at least 30 seconds to 30 minutes.
10. Sensitivity to motion shall be adjustable.

11. All adjustment mechanisms shall be concealed from view, but shall be readily accessible to maintenance personnel using common hand tools.
12. Fresnel lenses of passive infrared sensors shall be “masked” as required to prevent the sensors from detecting motion outside the areas they are controlling. Manufacturer shall provide masking tape which matches the color of the sensor.
13. Sensor shall be compatible with electronic ballasts, and shall have a 100% off switch with no leakage current to the load.
14. Unless otherwise instructed by manufacturer, set ultrasonic wallmount sensors for a 7 minute time delay, and passive infrared wallmount sensors for a 15 minute time delay.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

15. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements).

F. FACTORY COMMISSIONING

1. All occupancy sensor system(s) shall be completely commissioned by the manufacturer's factory authorized technician, who will verify all adjustments and sensor placement. **This shall occur prior to Agency move-in, but after installation of furniture systems, shelving, partitions, etc.**
2. Multiple site visits by factory authorized technician may be required depending on the project schedule. Include the cost of all site visits in the Base Bid.
3. If additional site visits by factory authorized technician are required due to construction delays, delays in delivery of furniture systems, or due to the Contractor's failure to adhere to the manufacturer's installation instructions, the cost of extra site visits shall be borne entirely by the Contractor.
4. Provide the Contracting Officer with at least five (5) working days written notification prior to each commissioning visit by the factory authorized technician.
5. Provide the manufacturer with at least ten (10) working days written notification prior to scheduling a commissioning visit by the factory authorized technician. Provide all necessary assistance to factory authorized technician during the site visit, and immediately correct any deficiencies discovered during inspection.
6. Prior to Agency move-in, but after commissioning of occupancy sensor system(s), a

factory authorized technician shall provide training to the facilities maintenance personnel in the adjustment and maintenance of the sensors. This training shall not exceed a total of four (4) hours.

2.07 EXIT SIGNS

A. GENERAL

1. Exit signs and exit sign conversion kits shall be provided and installed in the quantity, type, and wattage specified.
2. Exit signs and exit sign conversion kits shall be furnished completely assembled with wiring and mounting devices and ready for installation at the locations indicated on the drawings.
3. Exit signs and the installation of exit signs shall meet UL 924 requirements and conform to NFPA 101 (Life Safety Code), NEC (National Electric Code), all applicable standards of OSHA, and all appropriate Federal, state, and local codes.

INCLUDE THE FOLLOWING ITEM IF NEW SIGNS ARE BEING SPECIFIED.

4. Existing exit signs shall be removed as directed by scope of work. Proper disposal of components shall be conducted according to the NRC (Radioluminescent Signs) and all relevant Federal, state, and local agency regulations or guidelines. Contractor shall provide Contracting Officer with verification of proper disposal.

INCLUDE THE FOLLOWING THREE ITEMS IF COMPACT FLUORESCENT SIGNS ARE BEING SPECIFIED.

5. Lamp installation and removal shall be easily accomplished without special tools. Attachments shall be secure and achieved with captive, non-removable fasteners.
6. Ballast replacement shall be accomplished without removal of the luminaire or the need for special tools.
7. All exit signs and exit signs with conversion kits shall be clearly marked for operation of specific lamps and ballasts. For maintenance purposes, the following lamp characteristics should be noted, as applicable, in the format "UseLamps Only":

Lamp diameter code (T-5), tube configuration (twin), and nominal wattage. Pin configuration and start type.

All markings shall be clear and located to be readily visible to service personnel, but invisible from normal viewing angles when exit sign is in place.

8. All elements of exit sign, lampholders, and connective wiring shall be tightly grounded.

9. Ceiling mounted exit signs shall be designed and installed to be supported independent of the ceiling.

10. Materials and Fabrication:

- a. Unless otherwise noted, exit signs shall use only completely concealed hardware. Latching of exit sign door frames shall be unobtrusive. Exit signs shall be free from light leaks by the inherent design of the body and frame. Gaskets, when used, shall be bonded to the exit sign casing.
- b. Exit signs shall be constructed with the minimum number of joints. Unexposed joints shall be accomplished by welding, brazing, screwing or bolting. Soldered joints are not acceptable.

11. Exit signs shall be rated for operation at the specified voltage.

12. Exit signs and retrofit kits shall be fully warranted for minimum of 5 years unless otherwise noted.

B. NEW EXIT SIGNS

1. Exit signs and exit sign installation shall comply with 2.04.A., General, above.
2. Compact Fluorescent Lamp Exit Signs
 - a. Exit signs shall be uniformly rear-illuminated with twin-tube compact fluorescent lamps
 - b. Power requirement shall be no more than 10 watts per exit sign.
 - c. Exit signs shall include the following:

Exit Sign Type "___": (Description of Exit Sign)

Sign Format: (Edge-lit, Matrix, Panel, Stencil)

Compact Fluorescent Lamps: (Quantity per exit sign, lamp diameter, base type, simultaneous burn)

Ballasts: (Quantity per exit sign, type)

Color: (Letters and Background)

Mounting: (Wall, ceiling, surface, pendant)

Housing: (Nominal dimensions, material, finish)

Impact Resistance/Tamper Resistance Requirements

Battery Info: (Battery or no battery, battery type, battery operating time, low-battery voltage disconnect, auto discharge/recharge cycle)

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- d. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements)

3. Light Emitting Diode (LED) Exit Signs

- a. Exit sign shall be illuminated with solid-state (red, green) LED lamps supplied with the sign, protected behind a polycarbonate face shield.
- b. Power requirement shall be no more than 5 watts per exit sign face.
- c. Exit signs shall include the following:

Exit Sign Type "___": (Description of Exit Sign)

Sign Format: (Edge-lit, Matrix, Stencil)

(No diffuser, Diffuser, Prismatic Diffuser)

Color: (Letters and Background)

Mounting: (Wall, ceiling, surface, pendant)

Housing: (Nominal dimensions, material, finish)

Impact Resistance/Tamper Resistance Requirements:

Battery Info: (Battery or no battery, battery type, battery operating time, low-battery voltage disconnect, auto discharge/recharge cycle)

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- d. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements)

4. Electroluminescent Panel Exit Signs

- a. Exit sign shall be fully solid-state using electroluminescent panels as a light source.
- b. Power requirement shall be no more than 1 watt per exit sign face.
- c. Exit signs shall include the following:

Exit Sign Type "___": (Description of Exit Sign)

Sign Format: (Stencil)

Color: (Letters and Background)

Mounting: (Wall, ceiling, surface, pendant)

Housing: (Nominal dimensions, material, finish)

Impact Resistance/Tamper Resistance Requirements

Battery Info: (Battery or no battery, battery type, battery operating time, low-battery voltage disconnect, auto discharge/recharge cycle)

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- d. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements)

5. Radioluminescent Exit Signs

- a. Exit signs shall use sealed tritium gas tubes as a light source and have no power requirements.
- b. Exit sign housing shall be of high impact flame retardant (UL-94) plastic. Sign face shall be constructed of a .125" thick clear acrylic or polycarbonate sheet.
- c. Exit sign shall have a tamper proof assembly with no removable fasteners.
- d. The legend shall be constructed of non-glare polycarbonate, .015 thick, open letters, field programmable arrows, and white letters with background colors of red or green.

THE FOLLOWING CAN BE INCREASED IF LONGER LIFE SIGNS ARE DESIRED.

- e. Exit sign shall be fully warranted for minimum of 10 years.
- f. Exit sign shall include the following:

Exit Sign Type "___": (Description of Exit Sign)

Sign Format: (Stencil)

Color: (Letters and Background)

Mounting: (Wall, ceiling, surface, pendant)

Housing: (Nominal dimensions, material, finish)

Impact Resistance/Tamper Resistance Requirements

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

- g. Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements)

C. EXIT SIGN CONVERSION KITS (RETROFIT)

- 1. Exit sign kits and kit installation shall comply with 2.07.A., General, above.

THE FOLLOWING REFERENCE TO UL LISTING OR CLASSIFICATION MUST BE RESOLVED BASED ON AVAILABLE AND DESIRED OPTIONS FOR RETROFIT. SEE TECHNICAL NOTES FOR MORE INFORMATION.

2. Exit sign retrofit kit must be (UL Listed, UL Classified) for the existing exit signs.
3. Contractor shall consult existing exit sign manufacturer for written modification procedures which satisfy UL and other safety requirements. Before proceeding, Contractor shall provide Contracting Officer with written confirmation of original exit sign manufacturer's responsibility once exit sign is altered. If original exit sign manufacturer will not accept responsibility for altered exit sign then contractor must provide written verification that retrofit kit manufacturer will accept such responsibility.
4. Contractor shall arrange for mockup to assess installation, relamping, reballasting, appearance, and any variation in existing exit sign design. The Contracting Officer shall be present for mockup.
5. Conversion kits shall be installed in exact compliance with manufacturer's procedures for installation.

THE FOLLOWING MUST BE EDITED TO EXPRESS THE JOB REQUIREMENTS.

6. Compact fluorescent conversion kits shall be provided assembled, complete with a one-piece adapter bracket and the following:
 - a. Compact Fluorescent Lamps: (Quantity per exit sign, lamp diameter, base type, correlated color temperature, lamp watts, rated lamp life, sequential or simultaneous burn)
 - b. Ballasts: (Quantity per exit sign, type)
 - c. Kits shall have a power requirement not to exceed 11 watts per exit sign.
7. LED conversion kits shall be provided assembled and with all required adapters and mounting hardware. Kits shall have a power requirement not to exceed 3 watts per exit sign face.
8. Electroluminescent conversion kits shall be provided assembled and with all required adapters and mounting hardware. Kits shall have a power requirement not to exceed 2 watts per exit sign face.

ACCEPTABLE MANUFACTURERS ARE DEPENDENT UPON RECEIPT OF MANUFACTURER'S CERTIFICATE OF COMPLIANCE WITH SPECIFICATION REQUIREMENTS. SPECIFIER MAY PROVIDE A LIST OF ACCEPTABLE MANUFACTURERS OR RETAIN THE FOLLOWING STATEMENT.

Acceptable Manufacturers: (Dependent upon receipt of Manufacturer's Certification of compliance with specification requirements)

PART 3.0 - EXECUTION

3.01 GENERAL

A. INSTALLATION

1. Install luminaires complete with lamps, as indicated, and with equipment, materials, parts, attachments, devices, hardware, hangers, cables, supports, channels, frames and brackets necessary to make a safe, complete, and fully operative installation.
2. Coordinate with other trades as appropriate to properly interface installation of luminaires and lighting controls with other work.
3. Install luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires, and secure in accordance with manufacturers' directions and approved shop drawings. Conform to the requirements of National Electrical Code ANSI/NFPA 70.
4. Specified or indicated mounting heights are to be to the bottom of each luminaire for suspended and ceiling-mounted luminaires, and to the center of each luminaire for wall-mounted luminaires. Obtain approval of exact mounting for luminaires on the job before installation is commenced and, where applicable, after coordinating with type, style, and pattern of ceiling being installed.
5. Ground non-current-carrying parts of electrical equipment in accordance with UL and NEC provisions.

B. FIELD QUALITY CONTROL

1. Upon completion of installation of luminaires and lighting controls, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning equipment at site, then retest to demonstrate compliance. Otherwise, remove and replace with new equipment, and proceed with retesting. Dates and times for all field tests are established by Contracting Officer. Coordinate all test requirements with Contracting Officer.
 - a. For normal and emergency building lighting, upon completion of installation, conduct an operating test to show equipment operates in accordance with requirements of this section.
 - b. Test all wiring with an insulation testing instrument, both before and after connection of luminaires and equipment. Minimum resistance shall be 250,000 ohms.
2. Upon completion of installation, luminaires and lighting equipment shall be in first class operating order and free from defects in condition and finish. At time of final inspection, all luminaires and equipment shall be clean, fully lamped, and be complete with required lenses or

diffusers, reflectors, side panels, louvers, or other components necessary for the function of the luminaires. Any reflectors, lenses, diffusers, side panels or other parts damaged prior to final inspection shall be replaced by Contractor prior to inspection.

- C. At the time of substantial completion and prior to field tests, replace lamps in luminaires which are observed to be noticeably dimmed after Contractor's use and testing, as judged by Contracting Officer.
- D. Furnish stock or replacement lamps amounting to 15% (but not less than one lamp in each case) of each type and size lamp used in each luminaire. Deliver replacement stock as directed.

3.02 ACCESSIBILITY

Install equipment such as junction and pull boxes, luminaire housings, transformers, ballasts, switches and controls, and other apparatus that shall be reached from time to time for operation and maintenance, to be easily accessible and appropriate for mounting and ceiling conditions.

MODIFY THE FOLLOWING SECTION TO ACCOMMODATE SPECIFIC
AGENCY REQUIREMENTS.

3.03 SUPPORTS

- A. Provide necessary hardware with luminaires, such as stems, plates, plaster frames, hangers and similar items, for safe luminaire support.
- B. Provide adequate support for the weight of the luminaires.
- C. Independently support luminaires from building structural elements.
 - 1. For round luminaires or luminaires smaller in size than the ceiling grid, provide a minimum of four rods or wires per luminaire, and locate at each corner of the ceiling grid in which the luminaire is located.
 - 2. Do not support luminaires by ceiling acoustical panels.
 - 3. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such luminaires independently or with at least two 3/4-inch metal channels spanning and wired to the ceiling tees.
 - 4. Provide rods or wires for luminaire support under this section of the specifications.
 - 5. Additionally, for recessed luminaires, provide support clips securely fastened to ceiling grid members, a minimum of one at or near each corner of each luminaire.
- D. Provide fastening devices of a positive locking type, which do not require special tools to apply or remove them. Do not use tie wires in place of fastening devices.

- E. Attach luminaire cones, louver assemblies or reflectors, which must be removed for lamp access, by means of safety chains to housings, which shall prevent them from falling. No part of the chain shall be visible after installation, when viewed from any angle up to 50° from the vertical.

3.04 CLEANING

- A. Immediately prior to occupancy, clean reflector cones, reflectors, aperture plates, lenses, louvers, lamps and decorative elements. To prevent static buildup on lenses and reflectors, clean with a manufacturer's recommended water-diluted solution of glass cleaner and allow to air-dry after installation.
- B. Upon completion of the luminaire installation and at the time of final inspection, luminaires shall be clean, and free from marks, dust, spotting or other defects. Replace any broken or defective parts prior to final inspection. Replace or make good all defects revealed by final inspection to the satisfaction of the Contracting Officer.
- C. Protect installed luminaires from damage during the remainder of construction period.

3.05 COMMISSIONING AND O&M MANUAL

- A. For any luminaire, ballast, or lighting control system, the contractor is responsible for a complete and operational system which is satisfactory to building manager and occupants. The Contracting Officer shall provide for or engage a commissioning agent to verify, with the assistance of the designer/specifier, that all components and system, as a whole, meet the design intent. This includes evaluation and verification of all adjustable features, such as time clock settings, sensitivity settings, high end trim, fine tuning, customized settings, etc. Contractor shall provide manpower and equipment after normal working hours to correct and adjust system, working with or without direct supervision of commissioning agent and designer/specifier until reasonable satisfaction has been achieved.
- B. The contractor shall assemble and submit, in bound 8.5"x11" format, an Operation and Maintenance Manual including product technical documents and cut sheets; manufacturer and product representative contacts; and operating and calibration instructions for all systems included in the upgrade, including but not limited to lamps, ballasts and lighting control devices. Manual shall include color-coded as-built drawings showing all lamp and ballast types to facilitate replacement. After approval by the Contracting Officer, this manual will be kept on site for reference use by facility maintenance personnel. Transfer of the document will include a thorough walk-through and demonstration of upgrade equipment by contractor for facility personnel, the designer/specifier, and the Contracting Officer. Contracting Officer shall schedule transfer.

END OF SECTION